LTE/LTE-Advanced Overview

Course Number: LTE4000-01EN | Duration: 2 Days

Target Audience

- UE & E-UTRAN Development Staff
- Network Engineering & Optimisation Personnel
- System Design Engineering Staff, IOT & System Test Engineers
- Technical Sales and Marketing Personnel

Prerequisites

- None

Learning Objectives

After completing this course, the students will be able to:

- Understand LTE key features and able to identify the major steps in the network architecture evolution towards an LTE network.
- Know the LTE network architecture, interfaces and protocols stacks.
- Describe OFDM, OFDMA, SC-FDMA concepts.
- Describe LTE air interface channel types and its characteristics.
- Know UE states and main signaling procedures.
- Explain different LTE voice services.
- Give example of LTE deployment scenario.

Course Outline

1. Introduction and Background
   - 1.1 Motivation and Major Steps in Network Architecture Evolution towards LTE
   - 1.2 Standardisation Bodies around LTE
   - 1.3 LTE Key Features
   - 1.4 LTE-Advanced Main Features
2. LTE Network Architecture and Protocols
   - 2.1 LTE/SAE Network Subsystem
   - 2.2 LTE/SAE Network Elements and its Functions
   - 2.3 Protocol Stacks and Network Interfaces
   - 2.4 LTE Roaming Architecture
   - 2.5 LTE Interworking Architecture with 2G/3G/Non-3GPP Networks
3. LTE Air Interface
   - 3.1 Multiple Access Concepts
   - 3.2 Basic of OFDM, OFDMA, OFDMA Signal Generation Concepts
   - 3.3 Basic of SC-FDMA, SC-FDMA Signal Generations Concepts
   - 3.4 LTE Subcarriers, Frame Structure , Resource Block and Modulation Options
   - 3.5 LTE Channel Structure
   - 3.6 LTE Channel Characteristics
   - 3.7 Basic of Multiple Antenna Technologies
   - 3.8 LTE Max. Bit Rate Calculation
   - 3.9 LTE UE Capabilities
4. UE States and Signaling Procedures
   - 4.1 UE States (ECM, EMM and ESM)
   - 4.2 Synchronisation and Cell Search
   - 4.3 Random Access
   - 4.4 RRC Connection Establishment
   - 4.5 Attach and Default Bearer Establishment
   - 4.6 Dedicated Bearer Establishment
   - 4.7 Tracking Area Update
   - 4.8 Intra-System Handover
   - 4.9 LTE Authentication Procedures
5. LTE Voice Services
   - 5.1 CSFB
   - 5.2 VoIP, Protocol Stack, ROHC
   - 5.3 VoLGA
   - 5.4 SRVCC
   - 5.5 TTI Bundling
   - 5.6 Semi-Persistent Scheduling
6. LTE Deployments
   - 6.1 Example of LTE Deployment Scenarios
   - 6.2 Radio Frequency Aspects
   - 6.3 FDD vs. TDD Aspects

LTE/LTE-Advanced Air Interface

Course Number: LTE4200-01EN | Duration: 4 Days

Target Audience

- System Design & Customer Support Personnel
- UE/E-UTRAN SW Developers and IOT/System Test Engineers
- Network Engineering & Performance Optimisation Staff

Prerequisites

- LTE/LTE-Advanced Overview (LTE4000-01EN)

Learning Objectives

After completing this course, the students will be able to:

- Know about different LTE releases (Rel. 8, 9, 10, 11) and the major feature additions in each release.
- State UE's optional and mandatory radio access capability parameters and features not tested.
- Understand how Carrier Aggregation operates with different CA Bandwidth Classes.
- Explain E-UTRA transmission modes and suitable antennas to enhance peak and/or cell edge performance.
- Describe LTE's HARQ operation in conjunction with eNodeB's link adaptation to maintain BLER target.

Course Outline

1. Evolved Packet System Network Layout
   - 1.1 E-UTRAN & Evolved Packet Core
   - 1.2 LTE-Uu Characteristics
   - 1.3 NAS & Access Stratum Identifiers
   - 1.4 Basics about Network Access (Signaling)
   - 1.5 HetNet and Relays
   - 1.6 HeNB
   - 1.7 CoMP
2. LTE Air Interface Design
   - 2.1 OFDMA & SC-FDMA
   - 2.2 LTE Bands & flexible Bandwidth Support
   - 2.3 Frame & Subframe Structure
   - 2.4 E-UTRA Transmission Modes & Antennas
   - 2.5 Channel & Bearer Concept
   - 2.6 Layer 1 Processing Steps
3. LTE Resource Allocation
   - 3.1 Resource Element & REG's vs. PRB
   - 3.2 Physical Channels & RE/RB Mapping
   - 3.3 Physical Signals & RE Mapping
   - 3.4 Dynamic Resource Block Assignment
   - 3.5 Uplink PUCCH Resource Assignment
   - 3.6 CQI Transmission
   - 3.7 Ack/Nack Transmission (DL/UL)
   - 3.8 Carrier Aggregation
4. Hybrid ARQ & Link Adaptation
   - 4.1 Convolutional & Turbo Coding
   - 4.2 Retransmission Combining
   - 4.3 MCS Selection & Link Adaptation
   - 4.4 Open Loop vs. Closed Loop HARQ
   - 4.5 HARQ Failure & Block Segmentation
5. MIMO
   - 5.1 Transmission Modes
   - 5.2 SU-MIMO
   - 5.3 MU-MIMO
6. Physical Layer Procedures
   - 6.1 LTE Cell Search
   - 6.2 RSRP & RSRQ Measurements
   - 6.3 System Information Decoding
   - 6.4 Random Access Procedure
   - 6.5 Paging Cycle & Monitoring
   - 6.6 Uplink Power Control (PUSCH/PUCCH)
   - 6.7 Sounding
7. RLC/MAC Operation
   - 7.1 PDCCH Order
   - 7.2 Timing Advance Update
   - 7.3 Scheduler Functionality
   - 7.4 Higher Layer SDU Processing
   - 7.5 RLC Status & L2 Retransmissions
8. PDCP Functionality
   - 8.1 Integrity Protection & Ciphering
   - 8.2 Robust Header Compression
   - 8.3 Lossless Handover
9. RRC Operation
   - 9.1 RRC Establishment Procedure
   - 9.2 RRC Re-establishment
   - 9.3 SRB & DRB Reconfiguration
   - 9.4 Measurement Control & Reporting
   - 9.5 LTE Mobility – Handover & Redirection
   - 9.6 Inter RAT Mobility
10. EMM & ESM Operation
    - 10.1 UE Voice Domain Preference & Usage
    - 10.2 LTE Attach & Default EPS Bearer
    - 10.3 Reasons for Tracking Area Update
    - 10.4 Dedicated EPS Bearer Activation
    - 10.5 IMS Discovery & Registration
    - 10.6 VoLTE & SRVCC Signaling

LTE/LTE-Advanced Signaling & Protocols on Uu Interface

Course Number: LTE4300-01EN | Duration: 4 Days

Target Audience

- UE/E-UTRAN SW Developers and IOT/System Test Engineers
- Network Engineering & Performance Optimisation Staff

Prerequisites

- LTE/LTE-Advanced Air Interface (LTE4200-01EN)

Learning Objectives

After completing this course, the students will be able to:

- Understand how EMM and ESM failure affect the UE's protocol behavior.
- Describe UE's tasks in priority based intra LTE and Inter-RAT cell reselection .
- Get behind the drawbacks and advantages of CSFB versus VoLTE with SRVCC.
- Explain E-UTRAN measurement events, reasons for handovers & RRC re-establishments.
- Set user plane & control plane parameters to reduce drops related to RLC, RRC & layer1.

Course Outline

1. UE's Idle Mode Procedures
   - 1.1 PLMN/Cell Search and Selection
   - 1.2 Priority based LTE Cell Reselection
   - 1.3 IRAT Priority based Cell Reselection
2. Physical Layer Procedures
   - 2.1 Random Access & PDCCH Order
   - 2.2 HARQ – Open & Closed Loop
   - 2.3 Layer 1 UL & DL Resource Allocation
   - 2.4 SU-MIMO/Spatial Multiplexing (DCI's)
   - 2.5 Beamforming & MU-MIMO (DCI's)
   - 2.6 Paging & System Info Transmission
   - 2.7 Semi Persistent Scheduling
3. RRC Connected Mode Signaling Procedures
   - 3.1 RRC Connection Re-/Establishment
   - 3.2 SRB & Radio Bearer Configurations
   - 3.3 RRC Measurement Controls
   - 3.4 Handover Signaling – RRC & Layer 1
   - 3.5 ANR and CGI Reporting for 4G/3G/2G
   - 3.6 DRX Configuration & Activation
4. LTE NAS & Application Layer Procedures
   - 4.1 EMM Attach & SGs-Discovery
   - 4.2 EMM Combined Attach & Tracking Area Update – Possible Failures, Reactions
   - 4.3 ESM Default EPS Bearer (IPv4v6)
   - 4.4 ESM Dedicated EPS Bearer Setup
   - 4.5 SIP De-/Registration Procedures
   - 4.6 VoLTE Bearer Configuration
   - 4.7 SRVCC from LTE to 2G/3G (CS Only and CS+PS Related Bearers)
5. Inter RAT Changes and Handover
   - 5.1 4G ⇔ 3G Handover (CS/PS)
   - 5.2 Redirections for CSFB and PS
   - 5.3 Redirections with SI and DMCR
   - 5.4 NACC & CCO (4G ⇔ 2G)
6. MAC Functions & Operation
   - 6.1 Transfer of higher Layer SDU's
   - 6.2 MAC Control Elements
   - 6.3 BSR & PHR Reporting
   - 6.4 Prioritised Bit Rate (PBR)
7. RLC Procedures & Functionality
   - 7.1 RLC-SDU Transfer between Peers
   - 7.2 RLC & MAC Interworking
   - 7.3 RLC Status & Retransmissions
   - 7.4 SDU Segmentation & Reassembly
   - 7.5 RLC-Counter, Timer & Max. Retransmission
8. PDCP Functions & Operation
   - 8.1 PDCP Headers – Control & User Plane
   - 8.2 ROHC for TCP/IP & RTP/UDP/IP
   - 8.3 Lossless Handover
   - 8.4 Ciphering & Integrity Protection
9. E-to-E User Plane Protocol Review
   - 9.1 Min. Overhead of MAC/RLC/PDCP
   - 9.2 Max. Possible Throughput per UE Cat
   - 9.3 Handover Delay's & SDU Stalling

LTE/LTE-Advanced Radio Planning

Course Number: LTE4400-01EN | Duration: 3 Days

Target Audience

- Network Planning/Performance Engineering Staff
- System Test/IOT Test Engineers and Optimisation Personnel

Prerequisites

- LTE/LTE-Advanced Overview (LTE4000-01EN) and LTE/LTE-Advanced Air Interface (LTE4200) or Equivalent Knowledge

Learning Objectives

After completing this course, the students will be able to:

- Name the fundamental approach to design the LTE radio network.
- Evaluate radio propagation and related phenomena.
- Understand the concept of coverage analysis by means of link budget and planning tools.
- Analyse capacity and dimensioning related aspects.
- State initial parameter tuning steps.
- Recall inter-frequency and inter-RAT related topics.
- Understand specific aspects of indoor and in-house deployment.

Course Outline

1. Introduction
   - 1.1 Generic Network Design
   - 1.2 Greenfield Approach
   - 1.3 Re-use of Existing Grids
2. Radio Propagation
   - 2.1 Fundamentals
   - 2.2 Pathloss Models
   - 2.3 Antenna Aspects
   - 2.4 Fading and Shadowing
   - 2.5 Indoor
3. Coverage Analysis
   - 3.1 UL/DL Link Budget and MAPL
   - 3.2 Cell Range Estimation
   - 3.3 Tool-supported Coverage Planning
4. Capacity Analysis
   - 4.1 Peak Data Rate vs. Practical T-Put
   - 4.2 Spectral Efficiency
   - 4.3 Capacity Estimation by Means of SINR, CQI, MCS
   - 4.4 Multi Antenna Deployment
   - 4.5 Capacity Enhancing Features
   - 4.6 Simulation Tools
5. Traffic Modeling
   - 5.1 QoS-Aspects
   - 5.2 Time Variations
   - 5.3 Spatial Distribution
   - 5.4 Traffic Simulation
   - 5.5 Traffic Forecasting
6. Dimensioning
   - 6.1 Coverage Requirements
   - 6.2 Capacity Based Approach
   - 6.3 Verification and Related KPI
7. Initial Parameter Settings
   - 7.1 PCI
   - 7.2 DMRS
   - 7.3 PRACH/RACH
   - 7.4 PUCCH
8. Inter-Frequency and Inter-RAT
   - 8.1 RF Considerations
   - 8.2 Load Aspects
   - 8.3 Idle Mode Mobility
   - 8.4 Connected Mode Mobility
9. Indoor/In-house Planning
   - 9.1 Indoor Propagation Models
   - 9.2 Additional Losses
   - 9.3 Coverage Calculation
   - 9.4 Capacity Estimation
   - 9.5 In-house Deployments

LTE/LTE-Advanced Parameter Optimisation & Troubleshooting on Uu Interface

Course Number: LTE4500-01EN | Duration: 5 Days

Target Audience

- Network Planning/ Performance and KPI Engineering Staff
- Network Optimisation Personnel and System Test / IOT Engineers

Prerequisites

- LTE/LTE-Advanced Signaling & Protocols on Uu Interface (LTE4300-01EN)

Learning Objectives

After completing this course, the students will be able to:

- Evaluate drive-tests logs and critical signaling faults as well as procedure mistakes.
- Analyse RRC parameter settings and their performance impact on LTE-Uu.
- Optimise HO procedures and their related parameters to reach better network performance.
- Debug critical system problems in UE & E-UTRAN as well as interworking with Core and IRAT.
- Improve E2E network KPI's and Subscriber's quality of experience (QoE).

Course Outline

1. System Acquisition and Network Access
   - 1.1 Overview of E-UTRAN & EPC
   - 1.2 SIB Transmission & Parameterisation
   - 1.3 Paging & Tracking Area Capacity
2. Physical Channel Planning & Optimisation
   - 2.1 PCI Planning Guideline
   - 2.2 DM-RS Planning Rules
   - 2.3 PRACH Parameter Optimisation
   - 2.4 PUCCH Parameter Analysis
   - 2.5 PDCCH Configuration & Performance
   - 2.6 HARQ & RLC Parameterisation
3. RRC Connection and Bearer Optimisation
   - 3.1 RRC Connection Setup Parameter
   - 3.2 Default EPS Bearer & DRB Parameter (BSR & PHR Optimisation)
   - 3.3 Short & Long DRX Configuration and Impact on Battery Life
   - 3.4 Dedicated Bearer Parameter (SPS Parameterisation)
4. Idle Mode Mobility in Rel. 8 – Rel. 10
   - 4.1 Measurement Types
   - 4.2 Cell (Re-)Selection & Priority with RFSP
   - 4.3 Inter RAT (Priority) Reselection & Redirection – inherited Priorities
5. Connected Mode Mobility
   - 5.1 HO Events and Trigger Parameters
   - 5.2 Intra-LTE HO Parameter Analysis
   - 5.3 Inter-RAT HO Parameter Analysis
   - 5.4 CSFB Procedure Problems & Delays
   - 5.5 SRVCC HO for CS and PS – Cipher Issue
   - 5.6 ANR Performance for CGI Reading (HeNB/CSG's)
6. Power Control and Power Setting
   - 6.1 UL Power Control for Cell Edge UE's
   - 6.2 Open vs. Closed Loop Performance
   - 6.3 SRS – Timing Advance & Power Control
   - 6.4 DL Power Boosting for 64QAM
7. NAS Problems & their Root Cause Analysis
   - 7.1 Attach Accept Fail for CS & Rejects
   - 7.2 TAU Reject Causes and Reasons
   - 7.3 Reasons for PDN Connectivity Rejects
   - 7.4 Service & Extended Service Rejects
   - 7.5 Procedure Collisions (CSFB & QoS Modifications)
   - 7.6 MOCN & EPLMN Issues
8. Radio Performance Optimisation
   - 8.1 ICIC & eICIC
   - 8.2 Connection Drop Analysis – 7 Reasons
   - 8.3 Frequency Domain Packet Scheduler (Performance Improvements)
   - 8.4 Load-based SINR Deterioration
   - 8.4 MU-MIMO vs. SU-MIMO (DL/UL)
   - 8.5 MIMO Condition Number vs. RI & CQI
9. Throughput vs. Capacity Optimisation
   - 9.1 Three Ways to throttle UE's Throughput (QoS, eNB, Backhaul)
   - 9.2 TCP Parameterisation (WS vs. RTT)
   - 9.3 S1-Backhaul Issues & Clock Stability
10. SON – Self Organising Networks
    - 10.1 Review of SON Features from Rel.8
    - 10.2 Self Optimising Features from Rel. 9
    - 10.3 Minimisation of Drivetests (MDT)
    - 10.4 Geotracing/Tracking